SPECIFICATION

TITLE

"A METHOD AND APPARATUS FOR CLEANING OBJECTS IN AN AUTOMATIC CLEANING APPLIANCE USING AN OXIDIZING AGENT"

BACKGROUND OF THE INVENTION

[0001] Cleaning a soiled load of objects in automatic cleaning appliances generally involves the use of chemical energy (such as detergent), mechanical energy (such as through agitation of the object load in a wash liquor or the manner of dispensing the wash liquor against the object load, such as spraying) and/or thermal energy (such as through an elevated temperature of the wash liquor). Different combinations of these energy inputs provide various levels of soil removal from the load. Depending on the type of objects in the load, there may be attendant damage, such as when the load comprises fabric, resulting in the generation of lint or the fading of various colors of the fabric, etc. Other types of objects could be subject to chemical etching or other types of damage.

[0002] Numerous types of chemical wash additives are known, such as detergents which include surfactants and emulsifiers, as well as enzymes, all used to dissolve, loosen and/or remove various soils and stains. Additional chemical additives in the form of bleaches, such as chlorine-based bleaches have been used to effect soil removal, particularly on white fabrics, since such bleaches are effective to remove colors from fabrics as well. With a fashion trend changing from white fabric to vibrant colors, the use of chlorine-based bleaches has become problematic.

[0003] There has been a development of color-safe bleaches, such as oxygen-based bleaches, also referred to as oxidizing agents. One such oxygen bleach that has been receiving consideration is hydrogen peroxide. One of the potential drawbacks associated with oxygen bleaches is that they have an adverse effect on some of the components found within many detergent formulations. For example, the hydrogen peroxide can deactivate enzymes, thus decreasing the washing performance of automatic cleaning appliances.

[0004] The application of additives to the wash liquor places a thermal burden on the wash liquor, in those situations where the wash liquor is heated above ambient temperature to provide thermal energy to the soil removal process. Typically the additives are maintained at

ambient temperature, so additional energy is required to elevate the additives to the temperature of the wash liquor, or else the temperature of the wash liquor is detrimentally lowered upon the addition of the additives.

[0005] It would be an improvement in the art if a process were provided for utilizing an oxidizing agent in an automatic cleaning appliance that did not detract from the effectiveness of the chemistry of the wash liquor and which did not pose a thermal load on the wash liquor while the wash liquor is being applied to the objects in the elevated temperature enhanced wash process.

SUMMARY OF THE INVENTION

[0006] A method and apparatus for cleaning a soiled load of objects in an automatic cleaning appliance is provided which overcomes the problems noted above and permits the use of an oxidizing agent in an automatic cleaning appliance so that it does not detract from the effectiveness of the chemistry of the wash liquor and which does not pose a thermal load on the wash liquor while the wash liquor is being applied to the objects in an elevated temperature enhanced wash process.

[0007] In an embodiment of the invention, the method includes introducing a load of objects into a wash zone of the automatic cleaning appliance, applying a wash liquor and at least one of electromagnetic, chemical and mechanical energy to the load of objects in the wash zone to remove soil from the load of objects, and subsequently applying an oxidizing agent to the load of objects, through the medium of a fluid applied to the load of objects. By not applying the oxidizing agent simultaneously with the introduction of the wash liquor and energy to the object load, the problems described above are avoided.

[0008] In an embodiment of the invention wherein the wash liquor comprises a water based solution and there are enzymes in the solution, the oxidizing agent may be applied to the load of objects after a delay of a predetermined time following the application of the enzymes to the load of objects sufficient to allow the enzymes to work properly on the load of objects.

[0009] In an embodiment of the invention wherein thermal energy is applied to the load of objects by means of a heater being activated for a period of time to heat the wash liquor, the oxidizing agent may be applied to the load of objects after the heater is deactivated

in order to avoid posing a thermal load while the heat from the heater is being used to enhance the wash process.

[0010] The method of the present invention may be practiced in an automatic cleaning appliance wherein the wash zone is arranged to rotate about a vertical axis or where the wash liquor is dispensed from a rotating spray arm. In such a machine, the oxidizing agent may be introduced to the wash zone in a lower region of the wash zone in order to assure a proper mixing of the oxidizing agent with the wash liquor before it is introduced to the object load. An additional embodiment includes adding the oxidizing agent to the top of the wash bath after a majority of the working fluid has entered the bath. Optionally, the oxidizing agent may be introduced via a recirculation pump that takes fluid from the sump and re-introduces the flow into the top of the tub. Finally, the oxidizing agent may be added simultaneously to the lower region of the wash zone as well as the top half of the wash zone through a flow splitter or diverter valve. This option provides the aforementioned mixing advantage as well as providing direct contact of the oxidizing agent to the soiled objects.

[0011] The method of the present invention may also be practiced in an automatic cleaning appliance wherein the wash zone is arranged to rotate about a horizontal axis or, again, where the wash liquor is dispensed from a rotating spray arm. In such a machine, the oxidizing agent may be introduced into a sump where the wash liquor collects, and from where the wash liquor is pumped into the wash zone.

[0012] In an embodiment of the present invention, including an initial wash cycle during which at least one of electromagnetic, chemical and mechanical energy is applied to the load of objects, the oxidizing agent may be applied to the load of objects no sooner than approximately midway through the initial wash cycle.

[0013] In an embodiment of the present invention, wherein a first water based rinse cycle occurs after the application of at least one of electromagnetic, chemical and mechanical energy, the oxidizing agent may be applied to the load of objects during the first rinse cycle.

[0014] In an embodiment of the present invention, the oxidizing agent comprises hydrogen peroxide. In such an embodiment, the hydrogen peroxide may be provided in the fluid medium at a concentration in the range of 10 to 10000 parts per million, more preferably less than 2500 parts per million, and most preferably, less than 1000 parts per million.

[0015] In an embodiment of the present invention utilizing hydrogen peroxide, the hydrogen peroxide may be generated in the automatic cleaning appliance. Additional activation routes include introducing the oxidizing agent in a high pH environment (greater than 8) or activating through an electromagnetic source like ultraviolet or visible light with the addition of a catalyst.

[0016] In an embodiment of the present invention utilizing hydrogen peroxide, the hydrogen peroxide may be activated in the automatic cleaning appliance through contact with chemically modified surfaces to form hydroxyl radicals.

[0017] In an embodiment of the present invention, the automatic cleaning appliance may be provided with a water supply line for providing water to be used in the wash liquor and the hydrogen peroxide is generated in the automatic cleaning appliance through electrolysis of water introduced through the water supply line.

[0018] In an embodiment of the present invention, a method of cleaning objects in an automatic cleaning appliance is provided including the steps of introducing a load of objects into a wash zone of the automatic cleaning appliance, electrochemically decomposing a chemical composition into resultants via an electrochemical cell device arranged in the automatic cleaning appliance, applying a wash liquor and at least one of electromagnetic, chemical and mechanical energy to the load of objects in the wash zone to remove soil from the load of objects, and subsequently applying at least one of the resultants to the load of objects, through the medium of a fluid applied to the load of objects.

[0019] The present invention also contemplates an automatic cleaning appliance in which the invention can be realized.

[0020] In one embodiment, such an automatic cleaning appliance could include a wash chamber defining a wash zone for accepting a load of objects, a dispenser for applying wash liquor to the wash chamber, a sump for collecting wash liquor that has been applied to the wash chamber, and a chemical generating device for generating an oxidizing agent in the wash liquor.

[0021] In another embodiment, such an automatic cleaning appliance could include a wash zone arranged to receive a load of objects to be cleaned and a wash liquor to be applied to the load of objects, a water supply line communicating with said wash zone, a hydrogen peroxide generator arranged to receive a supply of water from the water supply line and a conduit leading from the hydrogen peroxide generator to the wash zone.

[0021] The objects cleaned in the automatic cleaning appliance could include porous fabric and textile objects, such as clothing, linens and similar materials, and could include non-porous ceramics, metals, plastics and similar materials made into dishes and other food preparation and servicing objects and utensils, as well as many different types of raw and manufactured components.

BRIEF DESCRIPTION OF THE DRAWING

[0022] Figure 1 illustrates a flow chart of various steps of a method embodying the principles of the present invention.

[0023] Figure 2 schematically illustrates an automatic cleaning appliance embodying the principles of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] The present invention is directed to a method for cleaning objects in an automatic wash system or cleaning appliance using an oxidizing agent, as well as for an apparatus to effect such cleaning.

[0025] Although a variety of oxidizing agents may be used in the method of the invention, one such agent is hydrogen peroxide, and this particular agent is discussed in detail below. However, it should be understood that the present invention is not limited to this particular oxidizing agent. Some additional chemical compositions include ozone, percarbonate, perborate, singlet oxygen, peroxy acids (RCO_3H), hypochlorite, chlorine and chlorine dioxide, metal oxyacids such as all forms of chromium (VI) and permanganate ion ($KMnO_4$), nitric acid, nitrous acid, sodium peroxide, halogens, but more specifically Br_2 and Cl_2 and compounds containing Cl^- and Br^- and mild oxidizing agents such as Ag^+ and Cu^{2+}.

[0026] Figure 1 illustrates an embodiment of the invention, which includes, in step 20, introducing a load of objects into a wash zone of the automatic cleaning appliance. In step 22, a wash liquor and at least one of electromagnetic, chemical and mechanical energy are automatically applied to the load of objects in the wash zone by the automatic cleaning appliance to remove soil from the load of objects. The wash liquor may be either an aqueous (water) based solution or a non-aqueous based solution, such as disclosed in U.S. Patents 6,451,066 and 6,045,588 which are incorporated herein by reference. The electromagnetic energy may be in the form of infrared (thermal), ultraviolet or microwave to heat or disinfect the object load, soil or wash liquor, or may be from other parts of the electromagnetic

spectrum. The chemical energy may be supplied via various detergent and other additives in liquid or gaseous form, which may also be applied in concentrated form, as disclosed in U.S. Patent 4,784,666 which is incorporated herein by reference. Alternative techniques for introducing the chemical energy including the oxidizing agent include foams, mists or vapors.

[0027] The mechanical energy may be supplied by agitating the object load in the wash zone by various means such as agitators, impellers, vanes, baffles and rotations or oscillations of the wash zone, or by spinning the object load at a high speed and applying a fluid wash liquor to the objects which is driven through or around the objects by the spinning action. Ultrasonic energy may be applied to the object load or the wash liquor to induce a mechanical agitation or vibration to assist in loosening or removing soil from the objects. The wash liquor may be applied to the object load in the form of sprays or jets to impart mechanical energy into the object load. Also, solid additives may be introduced to the object load to dispense chemicals or to increase mechanical energy being applied to the object load. Several exemplary arrangements are disclosed in U.S. Patents 5,191,667, 5,191,669, 5,219,370, 5,271,251, 5,345,637, 5,460,018, 5,507,053, 6,591,638, all of which are incorporated herein by reference.

[0028] In step 24, which is to occur subsequent to step 22, an oxidizing agent is applied to the load of objects, which may be through the medium of a fluid applied to the load of objects.

[0029] In this embodiment, the purpose for applying the oxidizing agent subsequent to the application of wash liquor and some type of energy, is to avoid the negative effects of the oxidizing agent on the various chemistry of the wash liquor if a chemical energy is used, such as in the form of a detergent with an enzyme additive, or to avoid the thermal load the oxidizing agent would place on the wash liquor if a thermal energy is used in association with the wash liquor, such as via heating the wash liquor to make it more effective in removing soils from the object load.

[0020] In an embodiment of the invention wherein the wash liquor introduced in step 22 comprises a water based solution and there are enzymes in the solution, the oxidizing agent may be applied in step 24 to the load of objects after a delay of a predetermined time following the application of the enzymes to the load of objects sufficient to allow the enzymes to work properly on the load of objects. For example, in a washing method which

includes an initial wash cycle during which at least one of electromagnetic, chemical and mechanical energy is applied to the load of objects as a step 22, the oxidizing agent may be applied to the load of objects in step 24 no sooner than some fixed time period, such as 5 minutes, or no sooner than approximately midway through the initial wash cycle. Alternatively, in a washing method which includes a first water based rinse cycle occurring after the step of applying at least one of electromagnetic, chemical and mechanical energy in step 22, the oxidizing agent may be applied to the load of objects as step 24 during the first rinse cycle.

[0021] In a wash method wherein the electromagnetic energy comprises thermal energy, the thermal energy may be applied to the load of objects by means of a heater being activated for a period of time to heat the wash liquor, such as prior to or during step 22, the oxidizing agent may be applied to the load of objects in step 24 after the heater is deactivated in order to avoid posing a thermal load while the heat from the heater is being used to enhance the wash process. Such a heater is intended to include all manners of heaters including those using electrical resistance, combustions of fuels such as natural gas or liquid petroleum, microwave heaters, etc.

[0022] In an embodiment of the present invention, the oxidizing agent introduced in step 24 may comprise hydrogen peroxide. In such an embodiment, the hydrogen peroxide may be provided in the fluid medium at a concentration in the range of 10 to 10000 parts per million, more preferably less than 2500 parts per million and most preferably less than 1000 parts per million. A suitable medium may be water, but other fluid mediums may be used as well. Some of these additional fluids are non-aqueous liquid solvents such as fluorinated solvents, perchloroethylene, siloxane-based solvents, hydrocarbon-based solvents, ionic liquids, liquid CO_2 and combinations thereof. More specifically, the fluorinated solvents are selected from the group comprising methoxynonafluorobutane, ethoxynonafluorobutane and decafluoropentane. The siloxane-based solvents can be selected from decamethylcyclopentasiloxane, dodecamethylpentasiloxane, decamethyltetrasiloxane and combinations thereof. Finally, gases, partially compressed gases and compressed gases including air and CO_2 may be an acceptable medium as well.

[0023] In some embodiments of the invention, the oxidizing agent may be applied to the load of objects in step 24 automatically, and therefore a supply of oxidizing agent may be stored in a reservoir in association with the automatic cleaning appliance, with an appropriate

dispensing mechanism provided to meter a desired amount of oxidizing agent onto the object load. For example, a storage reservoir may be located within the cleaning appliance cabinet, or may be located in proximity to the cleaning appliance cabinet, and connected thereto with a conduit. In some embodiments, the oxidizing agent may be generated in or near the automatic cleaning appliance, such as in optional step 26 (shown interposed between steps 22 and 24 with dashed lines) in Figure 1. For example, if the oxidizing agent is hydrogen peroxide, this agent may be generated via an electrochemical cell associated with the automatic cleaning appliance, so that a continuous supply of the oxidizing agent may be made available automatically, without requiring the user to periodically fill a reservoir with a supply of oxidizing agent. Specifically, the automatic cleaning appliance may be provided with a water supply line for providing water to be used in the wash liquor and the hydrogen peroxide may be electrochemically generated in the automatic cleaning appliance via the decomposition of the water introduced through the water supply line.

[0024] Such an arrangement is not limited to the generation of hydrogen peroxide. In an embodiment of the present invention, there may be included the step of generating an oxidizing agent via a chemical generator device arranged in the automatic cleaning appliance, applying a wash liquor and at least one of electromagnetic, chemical and mechanical energy to the load of objects in the wash zone to remove soil from the load of objects, and subsequently applying the oxidizing agent to the load of objects, through the medium of a fluid applied to the load of objects. While hydrogen peroxide is specifically described as one such oxidizing agent, formed in a reaction of hydrogen and oxygen, the resultants of an electrolysis of water, other oxidizing agents could similarly be formed. The chemical generator may be an electrochemical cell that decomposes a chemical composition, such as water, into resultants, such as hydrogen and oxygen, and then reacts at least one of the resultants to form an oxidizing agent, such as hydrogen peroxide. During the decomposition, the process can be combined with an oxygen-enrichment from air to further facilitate reactants. Other potential resultants could be ozone, hydroxyl radicals and metal containing hydroxides, depending on the purity of the inlet water.

[0025] In those embodiments of the invention utilizing hydrogen peroxide, the hydrogen peroxide may optionally be activated in the automatic cleaning appliance through contact with chemically-modified surfaces, such as in step 28 (shown interposed between steps 26 and 24 with dashed and dotted lines)of Figure 1, to form hydroxyl radicals before the

oxidizing agent is applied to the object load such as transition metal oxides, transition metal oxides doped with other elements including nitrogen and carbon, ferrous sulfate and ferrous sulfite.

[0026] A preferred embodiment utilizes titanium dioxide to activate the oxidizing agent and more-preferably nitrogen-doped or carbon-doped titanium dioxide.

[0027] Methods of producing chemically-modified surfaces include coating, particle impregnation, sputtering, vapor phase deposition, electroplating, plasma deposition, graphing and nano-technologies.

[0028] These chemically-modified surfaces may be used to delay the activation of the oxidizing agent in the process. Other methods that may be used to delay or control activating the oxidizing agent include are centrifugal switch activation, alternate paths in the machine such as re-circulation.

[0029] The method of the present invention may be practiced in an automatic cleaning appliance 30 such as shown schematically in Figure 2. Such cleaning appliance 30 could be an automatic clothes washer, an automatic dishwasher, or other types of automatic washers. In one such cleaning appliance 30, a wash zone 32 may be arranged to rotate about a vertical axis. In such a cleaning appliance 30, the oxidizing agent 36 may be introduced to the wash zone 32 in a lower region 38 of the wash zone in order to assure a proper mixing of the oxidizing agent with the wash liquor 40 before the oxidizing agent is introduced to the object load.

[0030] The method of the present invention may also be practiced in an automatic cleaning appliance 30 wherein the wash zone 32 is arranged to rotate about a horizontal axis. In such a cleaning appliance 30, the oxidizing agent 34 may be introduced into a sump 44 where the wash liquor 40 collects, and from where the wash liquor is pumped into the wash zone 32.

[0031] The cleaning appliance 30 could also include features such as rotating spray arms, fixed or moving jet outlets, and other known mechanisms for providing mechanical energy by means of the introduction or recycling of the wash liquor against the objects being cleaned.

[0032] As illustrated in Figure 2, the chemical generator device 48 associated with the automatic cleaning appliance 30 is provided which provides the generation of desired chemistries directly at or in association with the cleaning appliance. In some embodiments, a

continuous supply of the elements necessary to generate the desired chemistries can be connected to the device 48 so that the user need not periodically add chemistries to the device 48 or the cleaning appliance 30. In some embodiments, as described below, the generated chemistries are dispensed automatically to the cleaning appliance 30 avoiding the need for the user of the appliance to manually dispense the chemistries into the cleaning appliance.

[0033] The chemical generator device 48 is arranged in association with the cleaning appliance 30 which has the cleaning zone 32 where objects are cleaned. The chemical generator device 48 may be located within an outer cabinet 49 of the cleaning appliance, or may be located outside of the cabinet in a generally close proximity to the cleaning appliance 30. The chemical generator device 48 includes an inlet 51 to allow the introduction of at least one chemical composition. The chemical composition may be introduced through the inlet 51, such as by a user pouring or otherwise dispensing a discrete quantity of the chemical composition through the inlet 51, or a supply conduit 46 may be attached to the inlet 51 such that the chemical composition may be directed to the inlet through the conduit from a source of supply which may be a reservoir of a finite volume, or may be from a source of a relatively continuous supply. For example, if the chemical composition is water, the conduit 46 may be connected to a water conduit located in the building where the appliance is located, thereby providing a relatively continuous supply of water.

[0034] The chemical generator device 48 also includes an operative area 53 where a desired chemical composition is generated by utilizing the at least one chemical composition. An outlet 55 is provided at the chemical generator device 48 which is arranged to communicate with the cleaning zone 32 of the cleaning appliance 30. The outlet 55 may lead directly to the cleaning zone 32, or a separate conduit 50 may be provided between the outlet 55 and the cleaning zone 32. In the embodiments where the chemical generator device is located outside of the cabinet 49 of the cleaning appliance 30, such a conduit 50 is generally required.

[0035] In some embodiments, the chemical generator device 48 also includes a dispensing apparatus 57 arranged to dispense the generated chemical composition to the cleaning zone 32 from the operative area 53 through the outlet 55. In some embodiments, the generated chemical composition may be dispensed through the outlet via gravity, in other embodiments the generated chemical composition may be dispensed due to a pressure associated with the chemical composition being introduced through the inlet 51, or due to a

pressure developed during the generation of the generated chemical composition. In other embodiments, the generated chemical composition may be dispensed through the use of a pump. In an embodiment of the invention, the dispensing apparatus 57 is arranged to automatically dispense the generated chemical composition to the cleaning zone 32 during a cleaning operation of the cleaning appliance 30.

[0036] In most embodiments of the present invention a pump is used to move fluid between conduits, reservoirs, etc. These pumps may be positive displacement, kinetic or open screw mechanical pumps. Pumping is not limited to mechanical means and other types of pumps that be utilized are piezo-electric, electrohydrodynamic, thermal bubble, magnetohydrodynamic and electroosmotic.

[0037] It is another aspect of the invention to provide a control system 58. The control system 58 operates the dispensing apparatus 57 to deliver the oxidizing agent to the wash liquor to maximize performance by using sensors 59. Some types of sensors that may be preferred include pressure, pH, oxidation reduction potential, turbidity and conductivity. For example, hydrogen peroxide may be added to the wash liquor when the turbidity of the wash liquor suggests that the presence of particulate soils is low, thereby increasing the effectiveness of the oxidizing agent. Additionally, when the pH environment is optimal (greater than 8), then the oxidizing agent may be added to the system facilitating the production of hydroxyl radicals.

[0038] Where the cleaning appliance 30 uses an aqueous based wash liquor and therefore has a connection to a source of water; the water can be used as the initial chemical composition. In such embodiments, a fluid conditioning device 60 may be arranged in the water inlet line 46, which may include a filter mechanism or a chemical treating mechanism, such as a water softening mechanism. There are different types of filtering mechanisms that may be effective. For example, a metal, paper or coarse filter may be implemented at the inlet of the system. This filter will minimize particulate fouling of the electrochemical cell as well as increase the effectiveness of the oxidizing agent. This filter may be provided with a self-cleaning mechanism. Additionally, the inlet water or water directed to the electrochemical cell may pass through a fluid conditioning device such as a water softening mechanism. The purpose of this mechanism will be to reduce the contamination concentration of the water to less than 1000 parts per million of a calcium carbonate

equivalent, more preferably less than 500 parts per million and most preferably less than 100 parts per million. As a result, the performance of the system will be enhanced.

[0039] In an embodiment of the invention, the chemical generating device 48 further includes a storage space 61 arranged to receive a supply of material, such as a salt composition or a catalyst in solid form to be dissolved by fluid in the chemical generating device 48, or a fluid material to be dispensed into the chemical generating device during the generating process.

[0040] In an embodiment of the invention, the cleaning appliance 30 further includes a lockout mechanism 63 for an access door 65 used in loading objects into the wash zone 32. An activating apparatus 67 is arranged as a part of the control 58 for the lockout mechanism. The activating apparatus 67 includes a sensor 71 arranged to detect a concentration level of the predetermined chemicals in the wash zone 32, and upon detection of a level in excess of a predetermined level, the activation apparatus 67 will operate the lockout mechanism 63 via line 73 to prevent the door 65 from being opened.

[0041] The automatic cleaning appliance could include the water supply line 46 communicating with the wash zone 32. A chemical generator device 48, such as a hydrogen peroxide generator, may be arranged to receive a supply of water from the water supply line 46. The conduit 50 would lead from the chemical generator device 48 to the wash zone 32 to supply the oxidizing agent to the object load. Heat generated by the chemical generator device 48, such as through a transformation of the electrical power supplied to the chemical generator device, or heat given off during the generation of the chemical composition, may be utilized as all or a part of the electromagnetic, in this case thermal, energy applied to the load of objects in step 22.

[0042] In a preferred embodiment, the chemical system will utilize an electrolyte to increase the rate of reaction. Sodium chloride, NaCl, is a useful electrolyte and can be used to make certain bleaches. Potassium or sodium hydroxide are potential electrolytes. In the presence of water and electricity, NaOH and KOH produce hydrogen and oxygen which then in the presence of a catalyst can be used to make some bleaching compounds. Persulfates and peroxy salts are potential electrolytes. After an anodic reaction, persulfates and peroxy salts are in a mixture with hydrogen peroxide and other oxidizing agents. The hydrogen peroxide and oxidizing agents can be extracted from solution through steam distillation, contact with an ion exchange resin, contact with an adsorptive polymer or combinations

thereof. In a preferred embodiment, an anodic reaction produces hydrogen peroxide. The hydrogen peroxide is then extracted from the solution during the drying phase of an automatic cleaning appliance. The heat during the drying step can be used as a steam distillation technique and the hydrogen peroxide can be extracted and stored for future uses. Sodium carbonate, Na_2CO_3, can be used as an electrolyte and the resulting solutions could be potentially used to manipulate the pH of the wash liquor for the automatic cleaning appliance. In a preferred embodiment, carbonic acid is produced through the reaction and is subsequently used to fight food stains.

[0043] Electrodes for the chemical generating device can be coated with a variety of species. They can be coated with platinum, palladium, iridium or combinations thereof catalyst, coated surfaces. In addition, the surface can be zinc, tin or copper treated as well. Moreover, electrodes can take a variety of shapes: plate form, mesh, rod form, tubular form, comb form and punching metal.

[0044] Not all electrodes in the process participate in the chemical reaction. In an embodiment of the invention, supporting electrodes help with the conductivity but don't play a supporting role in the reaction.

[0045] The chemical generating device can be used for electrosynthesis. Types of chemicals that can produced by such a technique are: acetoin, acetylenedicarboxylic acid, adipoin dimethyl acetal, adiponitrile, 4-aminomethylpyridine, anthraquinone, azobenzene, S-carbomethoxymethylecysteine, L-cysteine, ethanol, hexafluoropropyleneoxide, perfluorinated hydrocarbons, polysilanes, salicylic aldehyde, succinic acid, ethylene glycol, propylene oxides, and sorbitol.

[0046] The chemical generating device as described above can be combined with, integrated with, placed in series or parallel with, before or after one or multiple chemical reactors. These reactor include but are not limited to bubble reactors, liquid dispersion reactors, tubular reactors, falling film reactors, trickle bed reactors, flooded fixed bed reactors, suspended catalyst bed reactors, or slurry reactors.

[0047] As is apparent from the foregoing specification, the invention is susceptible of being embodied with various alterations and modifications which may differ particularly from those that have been described in the preceding specification and description. It should be understood that we wish to embody within the scope of the patent warranted hereon all

such modifications as reasonably and properly come within the scope of our contribution to the art.